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ROCKS OF THE QUARRYVILLE QUADRANGLE, PENNA.

By

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Introduction.

The Quarryville quadrangle lies southeast of Lancaster and just east of the McCalls Ferry quadrangle described in Bulletin No. 62 of this series. The area is in Lancaster County, except a small part of Chester County east of Octoraro Creek included in the southeast corner of the quadrangle. The geologic mapping of the area was done in cooperation between the United States Geological Survey and the Topographic and Geological Survey of Pennsylvania and represents the joint work of Eleanora Bliss Knopf and Anna I. Jonas. Mineral developments of interest are limestone and slate quarries and a former nickel mine.

Drainage.

The quadrangle lies within the Piedmont upland region of southeastern Pennsylvania. The Susquehanna River, meaning "Great Island River," crosses the southwest corner of the quadrangle at Peach Bottom Station, 300 feet below the upland surface, between steep, rocky walls. All the streams of the area drain into the Susquehanna, but with the exception of Peters Creek, their lower courses are outside this quadrangle. The three most important streams, Octoraro, Conowingo and Pequea creeks, bear names derived from the language of the Indians who inhabited this country before its settlement by European colonists.

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The Rocks.

The rocks of the area, except the limestones, belong to the class known as crystalline schists. They originated as sediments and have been intruded by other rocks called igneous because they were once hot and fused. Both sediments and igneous rocks have been hardened and recrystallized since their formation and changed into schists. The term schist indicates that the rock is characterized by a texture, known as schistosity, by virtue of which it will split or cleave readily along a definite plane. The cleavage is owing to the development and parallel alignment of platy minerals such as mica and chlorite which themselves possess a strong cleavage.

The rocks of the area south of the Quarryville valley are crystalline schists which belong to one of the oldest eras of geological history, the pre-Cambrian, and form part of an extended belt that borders the southeastern upland country of Pennsylvania from the Delaware River at Trenton to the Maryland State line. The rocks of the southern upland area are of both sedimentary and igneous origin. Those derived from sediments were deposited in an ancient sea as gravel, sand and mud and covered by other and younger beds whose pressure, accompanied by heat from deeper in the earth, hardened them into sandstones and shales. Further alteration and recrystallization has converted them into crystalline schists.

Wissahickon formation. The oldest of these rocks is the Wissahickon formation which occurs in two different mineralogical facies. One facies, called oligoclase-mica schist, lies in the southeastern part of the area; the other, albite-chlorite schist, occupies a wide area in the central part of the quadrangle south of the Quarryville valley. These facies are separated by a band of Peters Creek quartzite and schist 5 to 6 miles wide which trends across the quadrangle N. 60° E. The oligoclase-mica schist or southern facies is a finely plicated, medium-grained rock composed of biotite, muscovite and quartz with a variable amount of feldspar as well as chlorite. Garnet is usually present. The albite-chlorite or northern facies of the Wissahickon formation is an albite schist interbedded with chlorite or muscovite schist. It is spotted with white crystals of albite that show most prominently on rough surfaces at right angles to the schistosity of the rock. Other minerals usually present are quartz, calcite, garnet, magnetite and tourmaline. Pyrite, present in most places, stains the rock a yellow color on weathering.

The Wissahickon formation is a gray to green sparkling schist which weathers into a brownish-red, clay soil sparkling with mica flakes and containing buff to red slivers of the schist. The two facies of the Wissahickon formation are of the same chemical composition and were deposited at the same time as an arkosic sediment, that is, a sand containing much unweathered feldspar. They differ in mineral content because of difference in the conditions under which they were recrystallized. The southern facies shows by its component that it was altered in a deeper zone with greater temperature and pressure than was the northern facies.

Peters Creek formation. The Wissahickon formation grades up into the overlying Peters Creek formation which consists of gray to green schistose quartzite interbedded with muscovite-chlorite schist. The Peters Creek contains more quartz and less feldspar than the underlying Wissahickon but on the upland weathers in about the same manner. The Peters Creek formation is well exposed along Peters Creek from which it was named and along Susquehanna River. It is closely folded and together with the underlying Wissahickon forms a series of schists whose thickness can only be estimated at about 4,000 or 5,000 feet.

Cardiff conglomerate. Above the Peters Creek formation are the Cardiff conglomerate and Peach Bottom slates. The Cardiff conglomerate occupies a narrow belt 10 miles long extending from West Branch of Octoraro Creek to Susquehanna River north of Peach Bottom. The Cardiff conglomerate surrounds the Peach Bottom slates except on the northwest side. It is a schistose conglomerate composed of quartz and sericite in which the quartz pebbles have been elongated and crushed. It is interbedded with blue and green slate. The conglomerate is not more than 100 feet thick and grades upward into the Peach Bottom slates.

Peach Bottom slates. The slates are blue-black, glistening, fine grained and of even texture, and have long been quarried for roofing. They are interbedded with a subordinate amount of crumpled blebby slates and chlorite schist.

Other pre-Cambrian rocks. High land extending across the northern valley area is an anticlinal uplift with a central core of pre-Cambrian crystalline schists. The higher part of this uplift is known as Mine Ridge. In this paper the term Mine Ridge uplift will be used for all the high land between the Quarryville valley and the Kinzers-Strasburg valley.

The crystalline schists in the core of the uplift extend from the eastern edge of the quadrangle nearly to Quarryville. The rocks observed are a series of mica schists and pebbly quartz schist. Outcrops are unusually scarce in the area, which is a fertile, well-cultivated country not deeply trenched by any stream.

The pre-Cambrian sediments in Mine Ridge uplift and south of the Quarryville valley were intruded in pre-Cambrian time by igneous material which has crystallized to form several types of igneous rocks.

Two rocks of granitic type occur in Mine Ridge uplift. They are light gray to pink crystalline rocks composed of quartz and feldspar with some mica and epidote. On the basis of the kind of feldspar present they are called albite alaskite and quartz diorite. These rocks weather readily and are seen as occasional boulders strewn on the surface.

The other pre-Cambrian igneous rocks are a series of gabbro-peridotite and pyroxenite which occur as fissure fillings or dikes and form narrow elongated areas at the surface. In Mine Ridge uplift

these rocks occur as a series of three parallel dikes that trend east and west. The rocks are dark green hornblende schists and serpentine derived from pyroxene rocks. The nickel ore body is associated with an area of hornblende schist at the head of Nickel Mines Run.

Serpentine. South of the valley there is a dike of serpentine that extends 3 miles across West Branch of the Octoraro at White Rock, a small area east of Tweedale and a larger body at the south edge of the quadrangle near Lyles. This is the northern extension of the chrome-bearing serpentines of the Pennsylvania-Maryland State line belt.

Cambrian rocks. The pre-Cambrian schists of Mine Ridge uplift furnish the basement on which was deposited a younger series of rocks belonging to the Cambrian period. At the base there is an arenaceous series which underlies Cambrian limestones. The arenaceous series, made up of the basal Hellam conglomerate, the Chickies quartzite, Harpers schist and Antietam quartzose schist, is exposed on the flanks of the uplift. The series forms a narrow band on the north side of Quarryville valley and a wider band on the north side and on the southwestern nose of Mine Ridge. The Harpers and Antietam members form hills that extend northwest of Mine Ridge to the western edge of the quadrangle. The Hellam conglomerate which unconformably overlies the pre-Cambrian rocks of Mine Ridge is a schistose quartz conglomerate and pebbly quartzite in which blue quartz grains are discernible. It forms the basal member of the Chickies quartzite and the two give rise to the prominent ridge which surrounds the uplift and which rises a hundred feet above the less resistant pre-Cambrian rocks of the central upland. The Chickies quartzite is white, vitreous, partly massive and partly thin-bedded and sericitic. It contains abundantly black tourmalines that are very noticeable on bedding surfaces.

The overlying Harpers and Antietam formations in this area are albite schists and their present character gives expression to the intensity of metamorphism which has affected them. They are gray, coarse to fine grained, sparkling, muscovite-biotite schists spotted with dull white albites. These schists contain quartz as an original constituent and in secondary veins. Both formations are calcareous and the Antietam becomes more so near the top and grades upward into a cream dolomite speckled with biotite. Weathering acts readily on these schists because of their calcareous nature and reduces them to a loose soil which is deeply gullied on hillslopes.

Vintage dolomite. The Vintage dolomite overlies the Antietam schist and forms the base of the limestone series. It is Cambrian in age but on the accompanying map is not separated from the overlyin Ordovician Conestoga limestone. The Vintage dolomite lies on the slopes of the Antietam schist hills and in valleys in the Conestoga limestone. It is a massive glistening gray to blue dolomite with some darker blue argillaceous beds. The Vintage dolomite is overlain by the Kinzers formation, lower Cambrian in age, composed of a series of shale and impure limestone beds exposed in the Quarryville quadrangle only in the cut of the Pennsylvania Railroad west of Kingers. The formation elsewhere is highly fossiliferous and its basal beds

in the Kinzers cut contain poorly preserved fragments of trilobites (extinct marine crustacea) and Salterella (small, elongate, tubular shells).

Conestoga limestone. Most of the valley area northwest and south of Mine Ridge uplift is underlain by the Conestoga limestone. It is Ordovician in age and overlies unconformably all the Cambrian sediments down to the Harpers schist. At the northern edge of the area it overlies the Kinzers formation. On the northwest side of Mine Ridge it overlies the Vintage dolomite, on the west side it rests on Antietam schist and on the south on Harpers schist. The Wissahickon formation bounds the Conestoga limestone on the south and the nature of this contact will be discussed later.

The Conestoga limestone is a strongly folded gray to blue crystalline limestone with partings of black graphitic slate. Near the base are lentils of coarse limestone conglomerate well exposed in the Bellemont quarries, one mile southwest of Kinzers, and at many other localities in the northern part of the valley. Farther south, from New Providence to Quarryville and in the Quarryville valley, the Conestoga limestone becomes a gray, micaceous limestone with pure marble beds that are closely folded like the adjoining schists. Fossils found in the Conestoga limestone near York determine the age of the formation as Ordovician.

Diabase. The youngest rock of the region is Triassic diabase which cuts the other rocks in a series of narrow dikes that trend about N. 25° E. In the northern part of the area diabase occurs in three parallel dikes crossing Mine Ridge uplift. In the schist upland south of the Quarryville valley the diabase occurs in five dikes trending roughly parallel to each other. Three of them extend to the Susquehanna River near Peach Bottom. The diabase, or trap, as it is popularly called, is a grayish black crystalline rock composed of small sparkling laths of feldspar and black augite. This is the only igneous rock of the region that has not been altered since consolidation.

Structure.

When the rocks of this area were laid down on the sea bottom as sediments they were in nearly horizontal beds, one layer above another. They were buried to a great depth by other sediments and while so buried were compressed vertically by weight of rock cover, and were subjected also to a lateral pressure acting on them from the southeast, the direction of the Atlantic Ocean. As a result of the lateral pressure the rocks were thrown into a series of parallel arches and troughs, and lifted above sea level. Erosion acting upon the rocks has removed the covers of the arches and troughs, that we call anticlines and synclines, and has produced the irregular surface distribution of the rock as we now see them. The linear direction in which the rocks trend is called the strike, which is southwest in this area. Mine Ridge uplift is a double anticline whose flanks are folded into many smaller anticlines and synclines. These anticlinal spurs of Mine Ridge anticline rise as hills composed of Harpers and

Antietam schist and extend to the western edge of the quadrangle. The valley rocks are also closely folded and fluted and the original bedding is difficult to discern. The limestones of the valley occupy synclines north and south of Mine Ridge uplift. The synclinal Quarryville valley is cut off on the south side by the closely folded rocks of the southern upland. These rocks form a wide syncline, the centre of which is occupied by the Peach Bottom slate and Cardiff conglomerate. These two formations dip steeply south and lie in a narrow overturned fold flanked on both sides by closely folded and more widely extended Peters Creek quartzite and schist and Wissahickon schist. While the major folding is thus wide and gentle it is accompanied by minor folding which has closely crumpled the rocks into smaller and smaller anticlines and synclines until the smallest folds are of dimensions seen in a hand specimen.

Lateral pressure not only bends rocks into arches and troughs but may incline these folds to the point of overturning. The rocks may give way under the strain and break as well as bend. As the result of continued lateral pressure blocks of rocks or parts of the earth's crust may be pushed over other blocks or parts, for short distances or for many miles. Such a break is called a thrust fault and the plane along which the rocks move is called the thrust plane. Faulting has occurred on the northwestern side of the Peach Bottom syncline. The slates were folded closely and overturned until both limbs of the fold dip southeast. After overturning the fold suffered an increased movement along the plane of overturning and this resulted in a rupture that squeezed out the Cardiff conglomerate on the northern limb of the fold and shoved the Peach Bottom slates over the Peters Creek formation. A thrust fault of more considerable extent occurs in this area. The pre-Cambrian Wissahickon schist has been pushed from the southeast over Ordovician Conestoga limestone of the Quarryville valley. The trace of the fault plane on the surface is the sinuous northern boundary of the Wissahickon formation. North of this line the rocks that composed the overthrust-block have been removed by erosion. As erosion continues more of the overlying schist block will be removed and a greater extent of valley rocks will be uncovered. There are several thrust faults of no great extent north of Mine Ridge anticline near Gap and Kinzers.

Topography.

The Quarryville quadrangle exhibits two distinct topographic areas - a valley country and a dissected upland. The valley lies in the northern part of the quadrangle and is underlain by limestones that are less resistant than the harder crystalline schists that compose the upland and have been cut lower by erosion. The valley is divided into two parts by the Mine Ridge uplift which rises 300 to 400 feet above the valley level. Mine Ridge together with its outlying spurs extends across the quadrangle from east to west. It is underlain by crystalline schists and quartzites that are harder than the valley rocks.

The greater part of the upland area lies south of the valley and occupies two-thirds of the Quarryville quadrangle. This is a well-

dissected upland with flat-topped ridges rising 200 or 300 feet above the stream valleys. If these valleys were filled, however, the surface of the area would be a plain sloping southeastward from a height of 700 to 900 feet at the north to 400-600 feet at the south. This upland has been caused by the presence of the Wissahickon and Peters Creek schists, Cardiff conglomerate and Peach Bottom slates that are hard, compact, and not readily soluble. The effect of erosion has been much slower on these schists than on the limestone, and the difference in elevation between the plateau and the valley is explained by the difference in resistance of the underlying rocks.

Economic Features.

Limestone. The limestone belt in the northern part of the area contains stone that has a wide range of uses, for buildings, railway ballast and roads, and for making lime and cement. The largest quarry now in operation is at Kinzers on the north side of the Lincoln Highway. This is the E. L. Slaymaker quarry worked for crushed stone. The rock is a heavy bedded dolomite dipping gently north and quarried with the dip. West of Strasburg near Pequea Creek is the Zittle Brothers quarry, operated intermittently for crushed stone and the Aldus Zittle quarry northeast of Strasburg, worked for the same material. These quarries are in the Conestoga blue limestone. The quarry of the Quarryville Lime and Stone Co., north of Quarryville is in the micaceous marble facies of the Conestoga limestone. It is known as the Orchard quarry, opened in 1826. The stone is burned for lime and considerable pure marble is available in the quarry. Many quarries throughout the valley area are now abandoned or only worked to a small extent for local use. Many of them are in the marble conglomerate of the Conestoga. The J. P. McIlvain quarries at Bellemont are among the more important. Lime was burned there for many years but the kilns are no longer used and the quarries for the most part are idle. There are many old quarries around London Grove, Wheatland Hills, Lime Valley and New Providence from which much limestone has been taken in times past. The cheapness and availability of manufactured product has caused a decline in local lime burning but crushed limestone is in considerable demand for making roads and most of the limestone quarried at present is used for that purpose.

Sand. On the southwest end of Mine Ridge the quartzite has disintegrated into white sand which is dug for building and furnace sand. North of Quarryville there is a sand pit, opened by Leander Kunkel in 1921, and now operated in a small way.

Peach Bottom roofing slates. The Peach Bottom slates occur in a belt a half mile wide along Susquehanna River just north of Peach Bottom station and trend N. 50° E. It is reported that quarrying was begun in this area about 1777; it continued actively for more than 100 years. All the work was done in open cuts close together and near the river. The good slate alternates with non-productive beds and in following the valuable beds downward along the steep dip the workings became too deep to operate profitably. There was a great deal of waste to be disposed of and much of it was dumped where it

covered workable beds. Slate mining was revived near Peach Bottom in 1910 by Gorsuch Bros., who operated "The Old Peach Bottom quarry" until 1916. In 1930 this company built a mill north of Peach Bottom along the Columbia and Port Deposit branch of the Pennsylvania Railroad for crushing the waste slate into granules to be used for making slate-surfaced, prepared roofing. The Peach Bottom slates are glistening blue black slates of finest texture. They are both durable and non-fading and have covered buildings for over a hundred years without change in color or loss of strength. They have been used extensively on many buildings in the county and State and the even blue black color and excellent appearance of the roofs as well as their durability testify to the quality of these roofing slates.

Chrome ore. Three miles east of Susquehanna River in Fulton township there is an area of serpentine containing some chromite. This area lies 2 miles north of the so-called State-line serpentine belt of southern Pennsylvania and Maryland. Chromite is reported to occur at intervals along the northern boundary of this belt and also in the southern part of the Quarryville serpentine area. The Brown pit east of Little Conowingo Creek is the only mine known to have been opened in this area and it has been long abandoned and filled up. The ore occurs both as massive compact chromite in nodules and pockets of variable size in serpentine rehrue, and as a spotted ore in which grains of chromite are distributed through the serpentine. This spotted ore is known as "birdseye." The Fulton township-State line chrome deposits were the world's only source of chrome from the beginning of the industry until the Civil War. With the importation of Turkish and other foreign ores at a lower price the Pennsylvania deposits were relegated to the position of a reserve supply. Mining which revived in the area during the late war ceased with its termination.

Iron. Limonite occurs at many places in Providence, Eden, and Bart townships for the most part along the contact of the limestones with the schists. It was mined considerably for 40 or 50 years previous to 1885. The best ore was removed and the remaining deposits are believed to be small. At least, present conditions do not warrant mining the known deposits.

Nickel. The Gap nickel mines are situated in Bart township 3½ miles southwest of Kinzers at the head of Nickel Mines Run. Previous to 1893 they were extensively worked and for a long time furnished the world's supply of nickel.

The ore is associated with amphibolite schist intruded into the sedimentary core of Mine Ridge uplift. The amphibolite schist area is only 1 mile long and belongs to the series of basic dikes which trend east in Mine Ridge. Up to the present time nickel ore has been found only at the locality of the Gap mines in this State.

The presence of copper was discovered in 1718 in a spring deposit located near where one of the mine shafts was afterwards placed. Prior to 1744 and for over one hundred years afterwards the Gap mines were worked for copper but copper mining did not pay. After

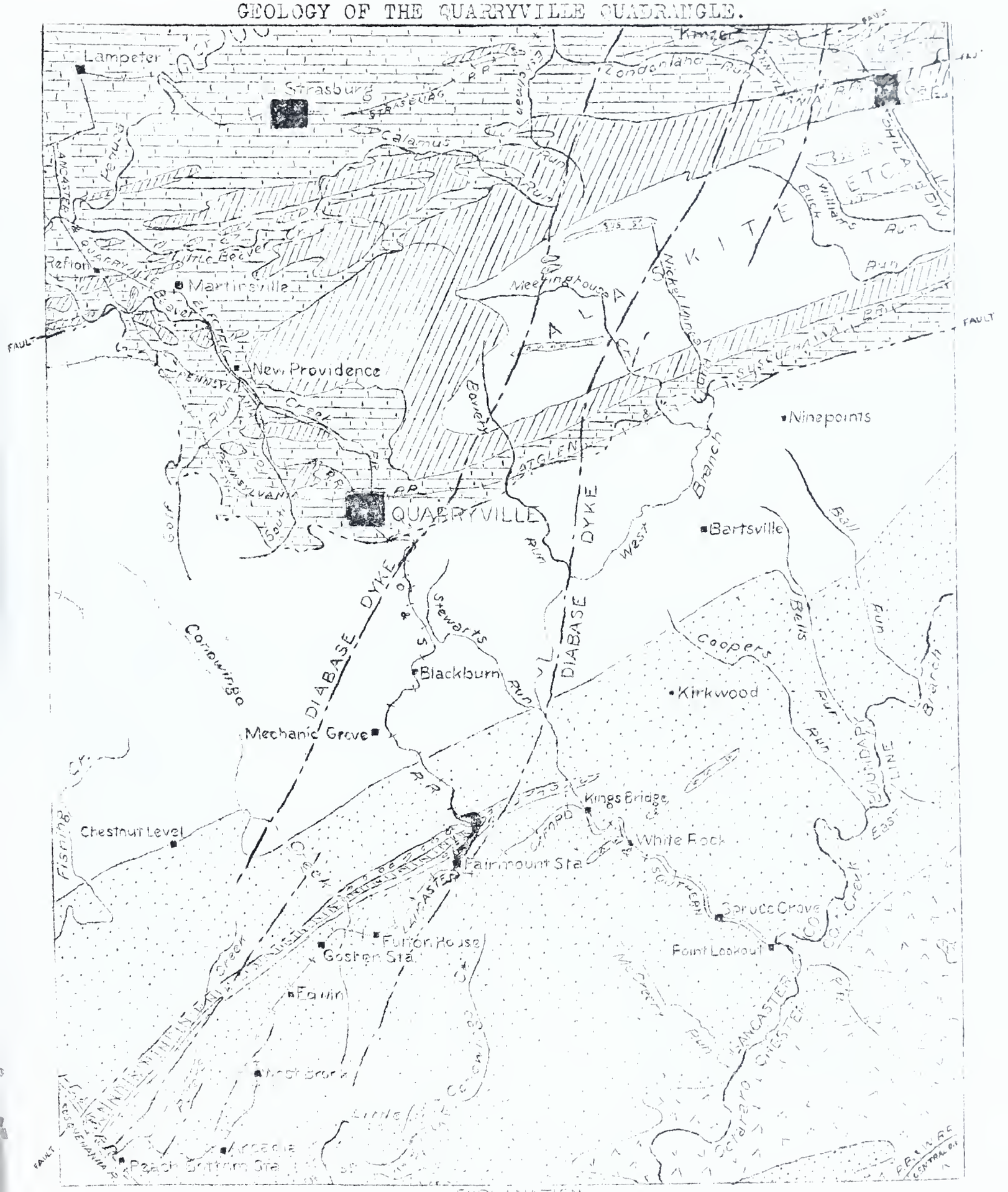
the nickel content was discovered the mines were taken over by J. A. Wharton who developed the property and built a smelter about one mile north of the shafts. The product was shipped to the American Nickel works at Camden, N. J. for final refining. Before operations ceased the mines produced more than 4,000,000 pounds of nickel ore.

The ore minerals are nickeliferous pyrrhotite and chalcopyrite and pyrite. Secondary millerite forms crusts and vein fillings. The ore minerals occur in a hornblende gangue and the ore body is in the form of pockets on the outer edge of the dike, especially on the east and southeast end. It disappears entirely on the west end. Lesser quantities of ore are irregularly distributed throughout the amphibolite mass in small lenses. The mines were located on the southeast and east side of the amphibolite area; the workings attained the depth of 250 feet and were from 4 to 30 feet wide.

The generally accepted theory of the origin of the ore is that it is a magmatic segregation of sulphides which separated out of the rock magma while it was still molten. The sulphides, pyrrhotite and pyrite, are the first minerals to crystallise from a gabbroitic magma rich in sulphur, copper, iron and nickel and they would tend to concentrate towards the walls.

The main mass of the magma crystallized after the sulphides into a pyroxene rock. The pyroxene has been subsequently altered to hornblende but the metamorphism did not affect the ore body.

GEOLOGY OF THE QUARRYVILLE QUADRANGLE.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QUARRYVILLE
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Fishing Creek
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Susquehanna River
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